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OBSERVATIONS ON THE ECOLOGY OF *GALAXIELLA PUSILLA* (MACK) (SALMONIFORMES:GALAXIIDAE) IN DIAMOND CREEK, VICTORIA

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Abstract: Aspects of the life history and diet of the dwarf galaxiid, *Galaxiella pusilla*, in Diamond Creek, southern Victoria, were studied between March 1983 and February 1984. *Galaxiella pusilla* inhabited the slow-flowing creek during the dry months of the year and moved to an adjacent swamp in early winter. Spawning occurred in late winter and early spring, when males possessed a mean G.S.R. of 9.8 and females a G.S.R. of 16.4. The diameter of the eggs of ripe females varied between 0.8 and 1.0 mm and the number of eggs per female varied between 66 and 247. Only one age class was found, suggesting that *Galaxiella pusilla* is an annual species. Length-weight analysis showed no deviation from isometric growth. *Galaxiella pusilla* is a generalist carnivore.

The genus *Galaxiella* McDowall includes the smallest representatives of the family Galaxiidae. Three species are currently recognised (McDowall 1978): *Galaxiella nigrostriata* (Shipway) and *Galaxiella munda* McDowall, both of which occur only in Western Australia, and *Galaxiella pusilla* (Mack) which is found in southern Victoria, on Flinders Island and in north-eastern Tasmania (McDowall & Frankenberg 1981).

Whilst some taxonomic studies and accounts of the distribution have been published (see McDowall & Frankenberg 1981, Cadwallader & Backhouse 1983), little is known about the biology of *G. pusilla*, although observations of the spawning behaviour in aquaria have been reported (Backhouse & Vanner 1978). The secretive nature of the fish and its characteristically small populations may account for this lack of attention. This study is an account of the growth, development, reproduction and diet of *G. pusilla* from one locality in Victoria.

METHODS

Galaxiella pusilla was collected monthly from Diamond Creek, 5 km south-east of Tonimbuk, Victoria. Diamond Creek is a tributary of the Bunyip River which it joins about 1 km downstream from the collecting site.

During the summers of 1982-83 and 1983-84 the creek at the collecting site flowed in a narrow channel up to 6 m wide. However, during the intervening wet period the creek overflowed into an adjacent swamp (a regular occurrence) and water covered an area of about 2 ha to a maximum depth of 1.5 m. While the swamp was dry, sampling was conducted only in the creek proper, but when the swamp filled, both the creek and the swamp were sampled.

Fish were collected using a long-handled dip-net with a 1 mm mesh and a 210×250 mm mouth. Fish were preserved immediately in 10% buffered formalin and within 24 h of collection were wet weighed to the nearest 10 mg and their total lengths (TL) measured to 0.1 mm with vernier calipers.

The gonads of *G. pusilla* were observed and staged according to a scheme modified from Pollard (1972). Gonads were classed in six stages rather than seven as Pollard (1972) used. The six stages were: 1—not developing; 2—developing; 3—maturing; 4—mature; 5—ripe; and, 6—spent. Gonads of sexed fish were removed and weighed. The weight was expressed as a percentage of the total weight of the fish: the gonadosomatic ratio or G.S.R. The diameters of thirty eggs from each ripe female were measured and the eggs from eight mature and ripe females were counted to determine fecundity. The stomach contents of 48 *G. pusilla* were analysed by the numbers method (Hynes 1950) from samples collected between March and September 1983.

RESULTS

Habitat

When collected from the creek proper, *G. pusilla* as well as the southern pigmy perch, *Nannoperca australis* Günther, were commonly found amongst emergent bankside vegetation. When the adjacent swamp filled, the two species were found associated with both submerged and emergent vegetation. Larval *G. pusilla* preferred open water although, when disturbed, they invariably took shelter in submerged vegetation.

Sex ratio

Of the 158 *G. pusilla* collected, 73 were adults; the remainder were larvae and juveniles. Of the 73 adults, 28 were males and 45 were females. The sex ratio was 1:1.6 which does not differ significantly from 1:1 ($X^2 = 3.96$, df = 1, $p > 0.05$).

Length-Frequency Analysis

Only one age class of *G. pusilla* was observed until the first juveniles were recruited into the population in August 1983 (Fig. 1). The fish increased in size from March until June, when growth ceased. Fish were first collected from the swamp in July (when the swamp first filled) and these individuals were found, on average, to be significantly smaller than in the previous month ($t=4.94$, $df=14$, $p=0.0001$). Growth then resumed until September, after which no adults were found. Larvae were first collected in August and these increased in size until January 1984. At this time, the swamp dried up and fish were collected from the creek proper again.

Length-Weight Relationships

The 'b' values, indicating condition of the fish (Le Cren 1951), proved not to be significantly different from the isometric value of 3 (Table 1). Males and females were compared by an analysis of covariance (Zar 1974) performed on the linear log-log plots to test for differences between slopes and between elevations. There was no significant difference between slopes ($F_{1,44}=0.8800$) or between elevations ($F_{1,45}=1.6306$).

Gonadal Development

Stages of Maturation

The sexes of the fish were distinguishable and the gonads had begun developing by the time the fish were between 3 and 4 months old (Fig. 2). When the fish were about 9 months old the majority had gonads at Stage 3 and could be sexed by eye. At Stage 4 the ovaries clearly distended the body wall, while the testes had not yet filled the body cavity. When both sexes were ripe (Stage 5) the females were considerably distended and the males possessed testes that filled the body cavity.

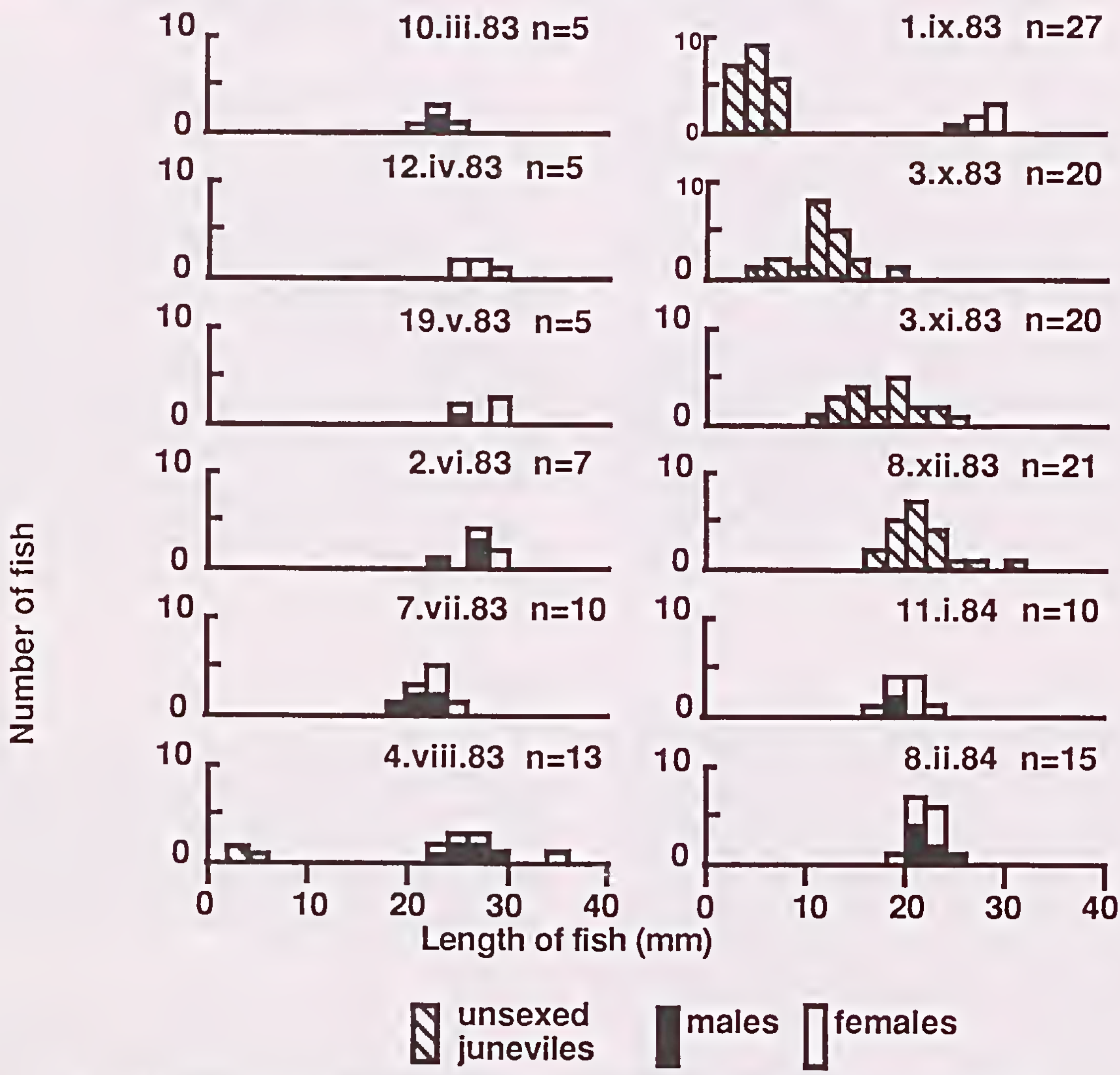

Fig. 1 — Length-frequency distributions for *G. pusilla*, collected at monthly intervals in Diamond Creek, Victoria.

TABLE 1

LINEAR MODEL OF LENGTH-WEIGHT REGRESSIONS FOR MALE, FEMALE AND TOTAL *G. pusilla* OF THE FORM logW = loga + blogL; VALUES OF b WERE NOT SIGNIFICANTLY DIFFERENT FROM 3.00 ($0.1 > p > 0.05$).

	N	a	b	F ratio	r^2
Males	28	0.83	3.05	107.65	0.81
Females	45	0.72	3.41	341.16	0.89
Total	73	0.73	3.36	465.55	0.87

In August the first ripe fish were collected from the swamp and the first larvae (represented by Stage 1 fish) were found. The absence of Stage 6 (spent) fish indicates either the death of fish after spawning or an emigration of all spent adults.

Gonadosomatic Ratios

The mean monthly gonadosomatic ratios for sexed *G. pusilla* are shown in Table 2. Not until May (when the fish were 8-9 months old), did the G.S.R.'s of the sexes differ substantially from each other. From May to September, in most instances, the ovaries contributed more to the weight of the female than the testes did to the weight of the male. In June, one male had an extraordinarily high G.S.R. of about 30 (all other males possessed gonads not in excess of 12), and this was the reason for the high mean G.S.R. attributed to males for that month. If this single specimen is excluded from analyses, the G.S.R.'s of both sexes peaked in August, at 9.8 for males and 16.4 for females.

TABLE 2

GONADOSOMATIC RATIOS FOR *G. pusilla* * = none in sample; † = GONADS OF JUVENILES TOO SMALL TO WEIGH (N) = NUMBER IN SAMPLE

Date	Male	Female
10. iii. 1983	0.97 (2)	0.93 (3)
12. iv. 1983	*	2.19 (5)
9. v. 1983	3.55 (1)	4.41 (4)
2. vi. 1983	12.28 (4)	10.92 (3)
7. vii. 1983	3.21 (5)	5.91 (5)
4. viii. 1983	9.84 (6)	16.44 (4)
1. ix. 1983	6.69 (1)	16.40 (5)
3. x. 1983	†	†
3. xi. 1983	†	†
8. xii. 1983	†	†
11. i. 1984	0.73 (2)	0.66 (8)
8. ii. 1984	0.70 (7)	0.94 (8)

Eggs and Fecundity

Ripe females possessed oocytes between 0.8 mm and 1.0 mm in diameter. Egg numbers varied between 66 and 247 (mean 150) per fish (TL range 23.7-36.3 mm). The relationship between fecundity of mature and ripe females can be described by the equation $F = 0.0044L^{3.0516}$, where F = fecundity, and L = length of fish ($r^2 = 0.8770$, $F = 43.1330$).

The adhesive eggs were deposited singly upon stems of emergent macrophytes within the swamp.

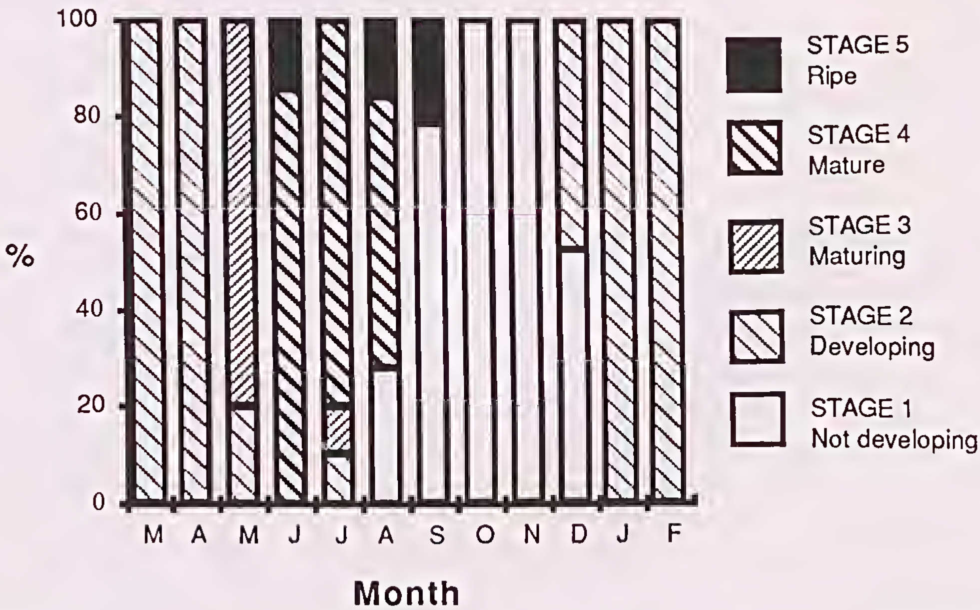

Fig. 2—Gonadal maturation stages for *G. pusilla* collected in Diamond Creek, between March 1983 and February 1984; sample sizes as in Figure 1 (male and female data pooled).

Diet

G. pusilla predominantly ate planktonic crustaceans, although chironomid larvae were often present in the stomachs in large numbers (Table 3).

When the fish first inhabited the creek proper, chydorid cladocerans and cyclopoid copepods were the dominant components of the diet, whereas daphniid cladocerans and harpacticoid copepods were present in large numbers in the stomachs of fish collected from the swamp. Ceratopogonids and collembolans were eaten in four months of the study, while terrestrial insects were eaten in most months and, although they were not taken in large numbers, the volume of each food item was considerable.

Table 3
Diet of *G. pusilla* ($N=48$) Collected in Diamond Creek between March and September 1983.

Food item	No. of items	% of total items
Diptera		
Chironomidae (larvae)	200	5.2
Ceratopogonidae (larvae)	17	0.4
Hemiptera (adult)	1	<0.01
Coleoptera (larvae)	2	<0.01
Terrestrial Insecta	40	1.0
Copepoda		
Cyclopoida	779	20.2
Harpacticoida	971	25.2
Calanoida	71	1.8
Cladocera		
Chydoridae	690	17.9
Daphniidae	427	11.1
Ostracoda	479	12.4
Crustacea (larvae)	11	0.3
Collembola	137	3.6
Hydracarina	2	<0.01
Terrestrial Araneae	2	<0.01
Unidentified	19	0.5

DISCUSSION

Galaxiella pusilla typically inhabits slow-flowing or still water bodies, such as creeks, drains and swamps. It is sometimes found in temporary waters and its continual reappearance in these habitats has led some authors to suggest that aestivation is used as a survival strategy (McDowall & Frankenberg 1981). The aestivating abilities of *Neochanna apoda* Günther and *N. burrowsius* (Phillips) have been well documented (Eldon 1978, 1979) and there is evidence to suggest that *Galaxias cleaveri* Scott can also aestivate (McDowall & Frankenberg 1981). However, the suggestion that the survival of *G. pusilla* during dry conditions involves desiccation-resistant eggs (McDowall & Frankenberg 1981) appears unlikely because of the timing of reproduction. In Diamond Creek, the fish spawned in late winter and early spring, the eggs hatched and the young were at least four months old before the swamp dried up. In the present study, all growth parameters (length, weight, maturation stages, egg size and G.S.R.) showed similar patterns of development: increase between March and June, a check in July, followed by a further increase leading up to maturity and spawning. The reason for this apparent check is unclear, but may be a function of small sample sizes and the fact that sampling was necessarily shifted to the swamp in July.

Female *G. pusilla* usually attain a maximum G.S.R. considerably greater than that of males, in common with *Galaxias vulgaris* Stokell, *G. maculatus* (Jenyns), *G. fasciatus* Gray and *Neochanna apoda* (see Cadwallader 1976, Pollard 1971, Hopkins 1979, Eldon 1979). *G. pusilla* spawns at the same time as most totally freshwater galaxiids (Campos 1972, McDowall & Frankenberg 1981, Fulton 1982). Conditions were favourable for spawning in Diamond Creek in late winter and early spring; the swamp was full and the aquatic vegetation luxuriant so that food resources were abundant and ample sites existed for the deposition of eggs. The size of eggs collected from ripe female *G. pusilla* was typical of non-migratory, freshwater galaxiids. Generally those galaxiids which migrate to estuaries or the sea as part of their life histories are thought to possess numerous small eggs, while those which spend their entire life in freshwater usually have a smaller number of large eggs (Benzie 1968, McDowall 1970).

It is suggested here that *G. pusilla* is an annual species, the adults dying after spawning. The samples collected indicate the presence of only one year class, although in August and September overlaps between one generation and another occurred as some adults had not yet spawned at a time when juveniles were already being recruited into the population. *G. pusilla* attains its maximum size within a year of hatching (unlike many other galaxiids which may take several years to complete growth) and aquarium observations indicate that *G. pusilla* die after spawning (Massola 1938, pers. obs.). If *G. pusilla* is an annual species, it may be unique among galaxiids, although *G. nigrostriata* and *G. munda* have not been studied sufficiently to draw any conclusions regarding their longevity. A large percentage of *Galaxias maculatus* are thought to die at the end of their first year, after spawning, however, some do survive and spawn in the following year (Pollard 1971).

G. pusilla is a generalist carnivore, which feeds mainly in the water column on zooplankton. Throughout the study, planktonic crustaceans and chironomids were the major food sources. These two food types were present in large numbers both in the creek and the swamp. The diet of *G. pusilla* is similar to those of other galaxiids which inhabit still or slow-flowing water bodies (McDowall & Frankenberg 1981). Backhouse and Vanner (1978) suggested that algae is a constituent of the diet of *G. pusilla* in aquaria. However, this did not appear to be the case in the present study. Furthermore, algae never constituted a part of the diet of wild fish even though it was abundant in many forms in the habitat.

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